I

Introduction: On discipline history

Histories of the scientific disciplines are not new, but in recent years historians of science have begun to write them in a new way. Older histories were often written by scientists turned historians and were insiders' accounts of the accumulation of more perfect knowledge.[1] They did not inquire why the world of knowledge is divided up as it is, or how it got that way, any more than naturalists before Darwin's generation worried about the origin and extinction of species. There was no particular reason for scientist historians to see how their disciplines were shaped by processes of social and economic adaptation and competition. Disciplines were the framework for descriptive natural histories of knowledge, not for analyses of the evolution and perpetuation of social forms.

Disciplines are political institutions that demarcate areas of academic territory, allocate the privileges and responsibilities of expertise, and structure claims on resources. They are the infrastructure of science, embodied in university departments, professional societies, and informal market relationships between the producers and consumers of knowledge. They are creatures of history and reflect human habits and preferences, not a fixed order of nature. There have as yet been few studies of sciences as institutions, and it is this aspect of the discipline of biochemistry that will concern me here. I will have less to say about biochemistry as a system of ideas than about biochemists' collective efforts to build and maintain their own institutions. The focus will be on how the symbiosis between biochemistry and medicine was established and how it shaped biochemists' practices. I shall show how different styles or programs of biochemistry developed as adaptations to particular institutional contexts.

The special appeal of studying the history of disciplines is derived from their dual functions as guides for intellectual and political

behavior. This was pointed out by both Charles Rosenberg and Russell McCormmach.[2] Rosenberg observed that disciplines are where individual and collective values meet:

> It is the discipline that ultimately shapes the scholar's vocational identity. The confraternity of his acknowledged peers defines the scholar's aspirations, sets appropriate problems, and provides the intellectual tools with which to address them; finally it is the discipline that rewards intellectual achievement. At the same time his disciplinary identity helps structure the scholar or scientist's relationship to a particular institutional context. His professional life becomes then a compromise defined by the sometimes consistent and sometimes conflicting demands of his discipline and the conditions of his employment.[3]

Disciplinary affiliation, far more than family, party, class, or even educational experience, shapes scientific careers and discourse. Because disciplines regulate intellectual traffic among scientific communities, they are indispensable for understanding innovations that may occur when academic boundaries and trade relations shift. Departments and professional societies mediate between science and the political, cultural, and economic institutions on which science depends for material and political support.

Disciplinary history also has strategic advantages for historians of science. It provides common ground for the "internalist" and "externalist" camps and opens communications with other historical specialties. Rosenberg hoped that the study of disciplines would encourage historians to accept science and medicine as aspects of social and intellectual history and would alert historians of science to the benefits of a broad historical perspective. For McCormmach, discipline history was a way of taking the blinders off the intellectual history of science without losing that distinctive emphasis differentiating the history of science from general history and justifying its existence as a distinct discipline. The intellectual benefits of discipline history are congruent with the strategic needs of historians of science to consolidate their discipline and win greater support from social, economic, and intellectual historians.

It is surprising, in view of its promise, how little discipline history has been done in the past 15 years. Disciplines have been invoked to explain the process of selection among different styles of science; Rosenberg's analysis of American styles of genetics is exemplary.[4] Disciplines have been used to explain the differential reception of particular theories of discoveries.[5] The style of research schools has been analyzed in institutional terms. For example,

Gerald Geison suggested, in his study of the Cambridge School of Physiology, how intellectual programs were shaped by the needs and opportunities of institution building.[6] But such studies by historians are rare. Sociologists of science, on the other hand, have been much concerned with the social basis of discovery and have been drawn to the study of networks of scientists working on common problems. They have not, however, generally been concerned with units as large as disciplines.[7] Moreover, by adopting, rather naively, the language of paradigms and consensus, sociologists have neglected the crucial role of historical experience and institutional context on the development of science.

There are signs of change, however. Several recent dissertations deal with departments and disciplines as political and intellectual entities: John Servos has written on physical chemistry in America; P. Thomas Carroll, on the University of Illinois department of chemistry; John O'Donnell, on American psychology. Dorothy Ross and Margaret Rossiter have laid the groundwork for comparative institutional histories of the social and agricultural sciences.[8] Daniel Kevles's book, *The Physicists*, although it does not attempt a systematic analysis of departments and styles, does reveal how American physicists were integrated into economic and political institutions.[9] Why this new interest in a program that has had its prophets for almost two decades? Perhaps we are feeling the effects of the burgeoning post-1960s academic market for "science and society" courses. For a new generation of historians of science, preserving the schism between "internal" and "external" methodologies has neither intellectual nor occupational benefits. Institutional and disciplinary history are ideal programs for a discipline with a heavy investment in intellectual history, adapting to a market that rewards a concern with the social and political aspects of science.

Some readers of this book may feel that the ideas of political economy – entrepreneurs, markets, constituencies, service roles – are overemphasized and the role of scientific ideas underrated. It may be that in some cases particular discoveries were indispensable resources for discipline building. But I do not believe, as I once did, that particular theories have, in general, a causal role in the creation of disciplinary institutions.[10] Some minimal level of intellectual achievement is, of course, a necessary condition for institution building. But intellectual achievement or the lack of it is not the reason why biochemists failed to build a discipline in nineteenth-century Germany or why they succeeded in America, a provincial

backwater if judged by research output. Differences in achievement cannot explain why the timing, location, and character of discipline building differed so markedly in the United States, Britain, and Germany. These patterns have to do with the political and economic support system of science: movements for reform of universities and medical schools, changing hospital practice, expanding markets for scientific professionals, and evolving division of labor among disciplines. The importance of political economy is evident in the two great episodes of discipline building: Germany in the midnineteenth and America in the early twentieth century.

Sociologists Joseph Ben-David and Avraham Zloczower invoked the idea of a decentralized, competitive academic market to explain why so many new biomedical disciplines were created in German universities between 1860 and 1880. They argued that in a decentralized system of state-supported universities competing for students and faculty, specialization was an effective strategy both for ambitious scholars and for university leaders. Organizing a new discipline was a way for smaller universities to attract top faculty, and the competitive market ensured that new specialties would be widely adopted once they were recognized in a few places.[11] Ben-David and Zloczower used a similar market argument to account for the ups and downs of achievement by German physiologists.[1] Their point was that the pace of scientific discovery does not depend on potential opportunities in nature or even on available facilities for research. Intellectual opportunities were exploited and facilities were created only when physiologists believed that achievement would be rewarded with specialized chairs, institutes, and stable budget lines. When every university had its chair of physiology, innovation declined, despite the existence of abundant facilities for research. The success of new disciplines in midnineteenth century Germany had to do with the institutional structure of the academic market and the political support for learning in the Second Empire.

The political economy of science in midnineteenth century German universities was in some ways a hothouse culture, not rooted in the provision of economic services.[13] This was not the case in the second great period of discipline building. In the early twentieth century, new applied science disciplines were created in German technical colleges and especially in American universities and their

satellite professional schools. But here too the crucial resources for discipline builders were less intellectual than economic and institutional, arising from new connections between science and agricultural and industrial development, and its sanctioning ideology of professionalism and the "service university." In his 1971 study of agricultural experimental station scientists, for example, Charles Rosenberg developed the idea of the scientist–entrepreneur.[14] He showed how scientist–administrators developed new professional roles that met legislators' and farmers' demands for practical results and also scientists' expectations of freedom to pursue basic research in their disciplines. Institutional contexts were created on the interface of academia and agricultural industry in which scientists could take greater responsibilities for economic growth and development and mobilize public support for science on an unprecedented scale, without compromising their disciplinary goals. Opportunities were created in experiment stations for a whole range of new agricultural disciplines. Other varieties of scientist–entrepreneurs performed similar mediating roles in government bureaus, industrial research laboratories, hospitals, social research commissions, and other institutions that utilized scientific knowledge for producing goods and services. An array of new basic applied sciences were created in schools of engineering, medicine, and social science, which provided skilled professionals for new science-based industries.[15] The establishment of biochemistry as a discipline was part of this historical process.

By World War I most scientific disciplines depended on public financial and political support to maintain their competitive position. A high level of research output and good connections with professional markets were crucial in the competition among disciplines or intradisciplinary styles. Political scientist Yaron Ezrahi offers a very suggestive account of how scientists use prevailing social beliefs and economic or political circumstances as resources for establishing their claims to public support.[16] Ezrahi depicts science as an interest group, not essentially different from any other group:

> The unprecedented degree to which science in America is dependent upon external material and political support in order to exist has compelled American scientists to engage actively and continually in competition with other social groups for their share of public resources and political support. . . . [T]he ability of science to grow and flourish depends no

longer merely on the free and successful use of intellectual resources, but also on its adaptability to political action and its capacity to convert its unique resources into effective means of political influence.[17]

Althogh Ezrahi is concerned mainly with the political authority of scientific theories in social policy making, his insights are equally applicable to the social processes that shape disciplines. A central theme of this book is that scientists and their allies use professional ideologies and social reform movements as resources to create disciplinary institutions. Underlying this argument is the belief that one cannot distinguish purely technical aspects of ideas from their role as political strategies in the competition for resources. Decisions about research programs, audiences, and department policies represent investments in a future market for scientific skills. Ideas are judged not only for their truth value but also for their utility in discipline building.

Rosenberg, Ben-David, Ezrahi, and others focus on different periods in the history of science, from the 1860s to the 1960s, and on different parts of the scientific enterprise, from academic ivory towers to the interface with production and the arena of national politics. But they share a conception of scientists as social actors in specific institutional contexts. They all use the language of competition, entrepreneurship, and resource management to understand the changing political map of scientific disciplines.

This conception of a political economy of science provides the central ideas for my analysis of discipline building in biochemistry. My main argument is that biochemists succeeded in establishing independent departments in American medical schools because the medical reform movement there offered opportunities that were not found in Germany or Britain. As medical colleges became postgraduate schools, elementary chemistry was relocated to premedical courses, and an essential service role was created for biochemists in the roster of preclinical disciplines. The belief of American medical reformers that science and scientific methods were crucial to medicine gave biochemists a key role in training physicians. Because of the historic weakness of the biomedical sciences in America, physiologists could not compete for biochemists' turf, as they did in Germany and Britain. American reformers' preference for standardized institutions and separate, specialized departments closed the door to alternative programs espoused by departments of physiology, chemistry, or biology. In Germany and Britain, the

lack of systematic reform movements and the presence of powerful claimants to biochemistry in physiology and other disciplines resulted in a more lively competition among disciplinary programs and a more protracted, less successful process of discipline building. This will be the jist of Chapters 1–6.

Disciplines are not homogeneous, consensual communities. They consist of diverse segments, often identified with competing styles or programs. These different programs are adapted to different institutional contexts, and, most important, they prescribe favored relationships with other disciplines. If disciplines are to the political economy of science what nations are to the political economy of production and commerce, then it is no surprise that their domestic affairs may be profoundly influenced by a diverse traffic in ideas and problems with neighboring disciplines. This is especially so for biochemistry, which must adapt to an unusual variety of powerful, sometimes domineering, neighbors.

Prior to 1940 there were at least three distinct styles of biochemistry: clinical, bioorganic and biophysical, and biological. One program took from biology its concern with a broad range of fundamental processes and its tolerance of tentative solutions. Another favored the narrow problems and stringent explanations that chemists prefer. A third prescribed the utilitarian problem solving of clinical science. Each defined a style by pointing to paradigms and constituencies in other disciplines. Analysis of these styles will be the burden of Chapters 7–11.

Briefly, the argument is that biochemists' programmatic conceptions of their discipline were shaped by institutional contexts and relationships, such as channels of recruitment, political alliances, and service roles. In American and many European universities, the biochemists' professional role was teaching medical students and training medical graduates in clinical investigation. Biochemists depended on clinicians for financial and political support, and clinicians depended on them for training and new diagnostic techniques. This symbiotic relationship shaped most biochemists' careers. Problems of clinical diagnosis were dominant intellectual interests for some thirty or forty years. Quite different relationships shaped the careers of those fewer biochemists employed in departments of chemistry, physiology, and biology. Physiologists valued biochemistry as an essential subdivision of their discipline. Consequently, biochemists enjoyed stable support but limited opportunities for

discipline building. In contrast, chemists saw biochemistry as an important external market for organic or physical chemists, but not as part of their discipline. Departments of chemistry almost never appointed biochemists to their staffs, but as the principal source of recruits, they profoundly influenced biochemistry. Biochemistry interacted with biology in still different ways. Traditional biologists mistrusted biochemists' reductionist views, and those interested in applying physics and chemistry disdained biochemists as narrow specialists. Very few biologists were recruited to biochemistry, and departments of biology seldom appointed biochemists. Chemical biology flourished in a few independent, self-consciously interdisciplinary institutes, insulated both from medicine and traditional biology. A few market relationships thus shaped the career options of recruits to the discipline.

The connection between institutional contexts and disciplinary styles, what Rosenberg has called the "ecology of knowledge,"[18] can best be seen by looking at university departments. Their mission is to embody and perpetuate disciplines. Programs are often discussed explicitly in connection with appointments to chairs, and these records are often available in university archives, an extremely rich and little-used historical resource. Individuals fashion programs out of their own experience but work them out in building departments. For example, the Cambridge biochemist F. G. Hopkins gradually developed a vision of biochemistry as a broadly biological discipline. His vision was manifested, not in his own research, but in his institute, which included individuals with competencies in microbiology, botany, embryology, and chemistry. It is possible to identify departments that exemplify other disciplinary styles and to relate these styles to the service roles that justified growth and influence. Departmental politics are often revealing of relations among disciplines. Many departments were established by physiologists, chemists and clinicians, and university administrators, who were concerned with the overall division of labor among the biomedical sciences. Innovations were thus stimulated or legitimated by criteria external to biochemistry. As the ecological metaphor implies, department programs were shaped by many actors and a process of adaptation to a complex social and economic environment.

2

Physiological chemistry in Germany, 1840–1900

As biologists have learned to see species as historical creations, not embodiments of some essential reality, so too must historians learn to think of disciplines as human creations, not subdivisions of a fixed natural order. The scope and thrust of biochemistry were, at crucial points in its history, very much up for grabs; at all times, they were subject to some degree of local interpretation. One must think of biochemistry in two complementary ways: as a body of work in the biomedical aspects of chemistry and as a political or institutional rubric that varies with time and locale. I use the term "biochemistry" to refer to the timeless extended family of biochemistries; when referring to specific historical groups, I use the terms they themselves used: physiological or pathological chemistry, medical chemistry, biological chemistry, *and* biochemistry, because that term too identifies a group of historical actors. "Biochemistry" has two meanings here, which is awkward, but inescapable.

Most academic disciplines originated in the rather brief period of active institution building in Germany, from 1840 to 1890. In physiological chemistry, as in most fields of science, Germany took a strong and early lead. Yet physiological chemistry was an anomaly; it was not a story of rapid and successful specialization and growth. Germans led in the production of biochemical research; but there were few institutions of physiological chemistry and these had little growth potential. This weakness became apparent after about 1900 when other countries, notably the United States, took the lead in institution building. This seeming paradox of intellectual success and institutional failure was, I believe, a consequence of the historical relationships of German biochemists with physiologists and chemists.

In most European universities, physiological chemistry evolved as a subdivision of physiology. Its association with physiology was not an inevitable consequence of the nature of that discipline, however. Physiological chemists were attached to physiology in the 1870s after a preceding generation had failed to establish their claim to the emerging specialty of organic chemistry. Only a few found careers in pathology, pharmacology, and hygiene, although chemistry was no less relevant there than in physiology. These patterns have more to do with institutional structures and strategies than with intellectual affinities.

Let us first look more closely at the anomalous pattern of discipline building. In 1905 Cambridge physiologist John Langley and clinician Thomas Clifford Allbutt cited impressive evidence of a biochemistry gap: in 1903, they claimed, 2,500 German workers published over 3,000 papers on chemical aspects of the biomedical sciences, whereas a handful of British workers published 70 papers, mostly of low quality. Although Britain and the United States had only 2 regular academic positions for biochemists, Langley and Allbutt counted 11 in Germany, 8 in Austria, and 15 in five other European countries.[1] Exaggeration of rivals' strengths was a regular part of the "neglect of science" game, of course, and Langley and Allbutt admitted that many of the continental positions were not in physiological chemistry as such. (Most, in fact, were attached to other disciplines.) Nevertheless, perusal of the *Biochemische Zentralblatt* bears out Langley and Allbutt's claim. Biochemical research was flourishing in institutes of chemistry, physiology, pathology, pharmacology, and clinical medicine.

Compared with these other biomedical disciplines, however, physiological chemists had few institutions devoted exclusively to their discipline. In 1906 the medical faculties of all 27 German-speaking universities had *ordinarius* (that is, full) professors of pathological anatomy, physiology, and hygiene, 24 had chairs of pharmacology, but only 9 had *ordinarius* professors of physiological chemistry. Four of these nine were less specialized chairs of "medical chemistry," including general chemistry, and three were combined chairs of pharmacology and physiological chemistry.[2] By 1918 three chairs had disappeared. The prospects for German biochemistry were less rosy than they seemed to be when viewed from across the Channel. In 1926 the Cambridge biochemist F. Gowland Hopkins drew a pointed contrast between the numerous